TOP-12-016: Measurement of the top polarization in the dilepton final state

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CMS Physics Analysis Summary

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Measurement of the top polarization in the dilepton channel

The CMS Collaboration

Abstract

A measurement of top quark polarization in $t\bar{t} \rightarrow \ell^+\ell^-$ events is performed in a data sample corresponding to a total integrated luminosity of 5.0 fb^{-1} collected by the CMS experiment in pp collisions at a centre-of-mass energy of 7 TeV at the LHC. In view of a significant excess reported in the top forward backward asymmetry at the Tevatron, the measured value is compared to the standard model expectation, and is found to be in good agreement.

Available on CMS information server **CMS AN -2012/190**

The Compact Muon Solenoid Experiment
Analysis Note
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17 May 2012 (v3, 01 June 2012)

Measurements of top-quark pair asymmetries in the dilepton final state at $\sqrt{s} = 7$ TeV

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Abstract

Measurements of several dilepton asymmetries in $t\bar{t} \rightarrow \ell^+\ell^-$ events are performed in a data sample corresponding to a total integrated luminosity of 5.0 fb^{-1} collected by the CMS experiment in pp collisions at a centre-of-mass energy of 7 TeV at the LHC. The observables include the lepton charge and the top charge asymmetry, the lepton azimuthal asymmetry, as well as the top polarization and spin correlation. In view of a more significant excess reported in related observables at the Tevatron for high $t\bar{t}$ system mass, the results are also given for $t\bar{t}$ system mass above 450 GeV. The measured values of these observables are found in agreement with their standard model expectations.

- http://cms.cern.ch/iCMS/analysisadmin/cadi?ancode=TOP-12-016

Introduction

- We want to measure the top polarization in the dilepton final state
- top decays before hadronization can wash out polarization
- charged lepton is best spin analyzer
  - $$\mathcal{P}_n = \frac{N(\cos\theta_{\ell,n} > 0) - N(\cos\theta_{\ell,n} < 0))}{N(\cos\theta_{\ell,n} > 0) + N(\cos\theta_{\ell,n} < 0))}$$
  - measured in the helicity basis (angle $\theta_{\ell,n}$ of lepton measured in parent top's rest frame, relative to direction of the top in the ttbar CM)
- Any significant difference from the SM expectation could be a signal of NP
- The work is inspired by this theory paper: http://arxiv.org/abs/1105.3743 by D. Krohn, T. Liu, J. Shelton, L.T. Wang

Analysis Strategy

- Use baseline event selections (with slight changes) from our search for heavy top-like quark pair analysis (EXO-11-050)
  - purpose of this selection is to reject events other than ttbar
  - EXO-11-050 is submitted to PLB
- Datasets: DoubleElectron, DoubleMu, MuEG collected by high p_T dilepton triggers
- Summer11 MC
- We measure the top polarization and differential cross-section in $\cos\theta_{\ell,n}$ at parton level after background subtraction and unfolding
- We also look at 2 signal regions where NP is expected to be more prominent

Event selection (preselection)

- Event cleaning: if >= 10 tracks; at least 25% purity; at least 1 good DA vertex (not isFake, ndf > 4, rho < 2 cm, z < 24 cm)
- 2 opposite sign isolated leptons: p_T > 20 GeV, |eta| < 2.5 (2.4) for e (μ)
- ≥2 pf jets with p_T > 30 GeV, |eta| < 2.5
  - loose pfjet ID (L1FastL2L3 corrected)
  - ΔR > 0.4 from all leptons passing analysis selection
  - ≥1b tags: CSVM
- MET > 30 GeV
- Z veto: 76<m_{ll}<106 GeV veto (for SF leptons)
- m_{ll}>12 GeV to veto low mass resonances (SF leptons)

Preselection Yields (5.0 fb^{-1})

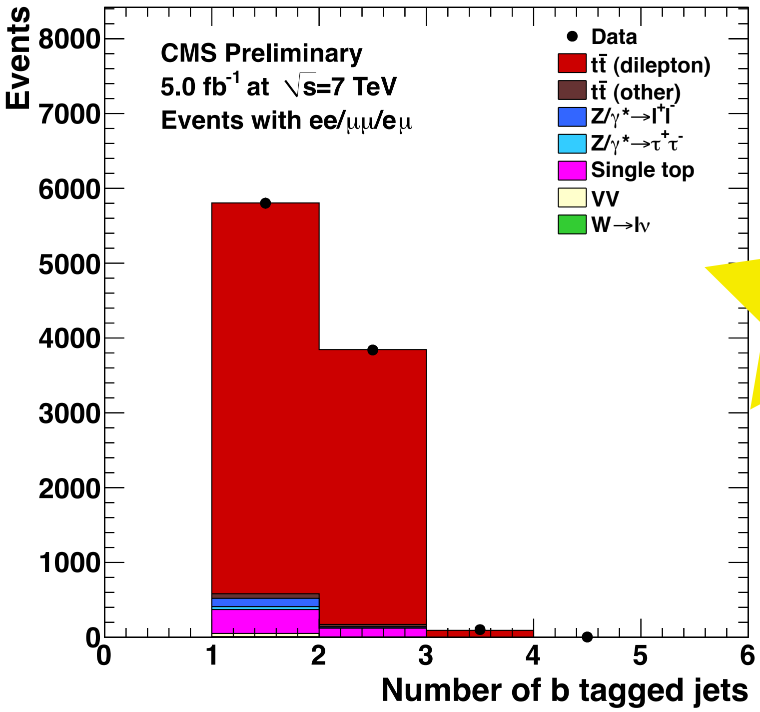
PAS

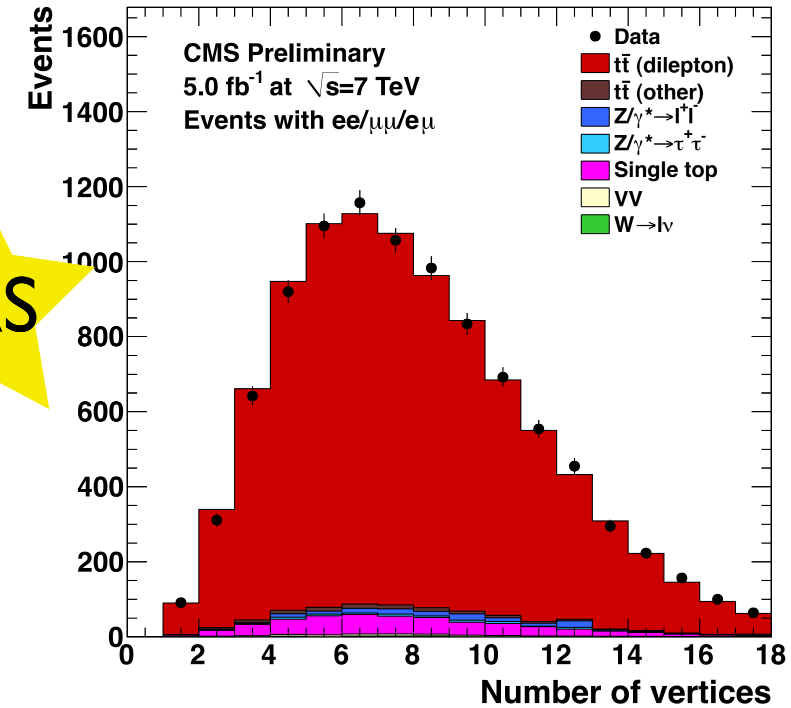
Sample	ee	$\mu\mu$	eμ	all
$t\bar{t} \to \ell^+\ell^-$	1791.7 ± 4.4	2127.3 ± 4.7	5069.4 ± 7.3	8988.5 ± 9.7
$t\bar{t} \to$ other	32.5 ± 2.9	4.8 ± 1.1	53.3 ± 3.6	90.7 ± 4.8
W + jets	< 1.9	4.7 ± 3.3	4.7 ± 3.4	9.4 ± 4.7
DY$\to$ ee	52.3 ± 5.8	< 0.6	< 0.6	52.3 ± 5.8
DY$\to \mu\mu$	< 0.6	72.8 ± 6.5	1.6 ± 0.9	74.4 ± 6.5
DY$\to \tau\tau$	17.6 ± 3.3	8.7 ± 2.2	18.7 ± 3.2	45.0 ± 5.1
Di-boson	10.6 ± 0.5	13.0 ± 0.5	24.0 ± 0.7	47.6 ± 1.0
Single top	84.9 ± 2.3	101.2 ± 2.4	252.1 ± 3.9	438.2 ± 5.1
Total (simulation)	1989.6 ± 8.8	2332.6 ± 9.3	5423.8 ± 10.3	9746.0 ± 16.4
Data	1961	2373	5412	9746

Uncertainties are statistical only

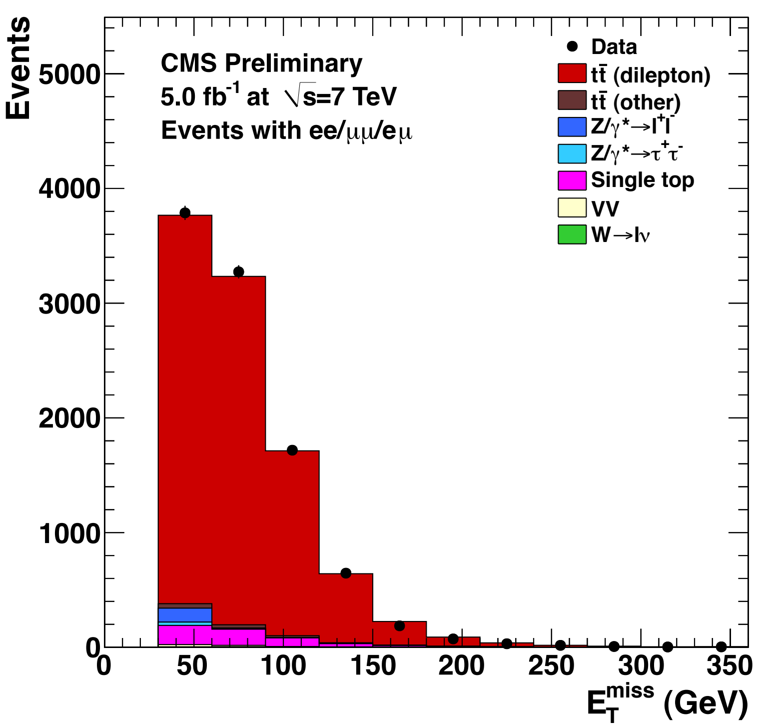
- MC events are weighted to match trigger efficiency, b tagging efficiency, and number of vertices distribution in data
- We use powheg-pythia for the $t\bar{t} \to \ell^+\ell^-$ component
  - normalized so that total MC yield matches data (corresponds to inclusive ttbar xsec of 167.7 pb)
  - $t\bar{t} \to \ell^+\ell^-$ contributes 92% of the total yield
- Comparison plots on next slide

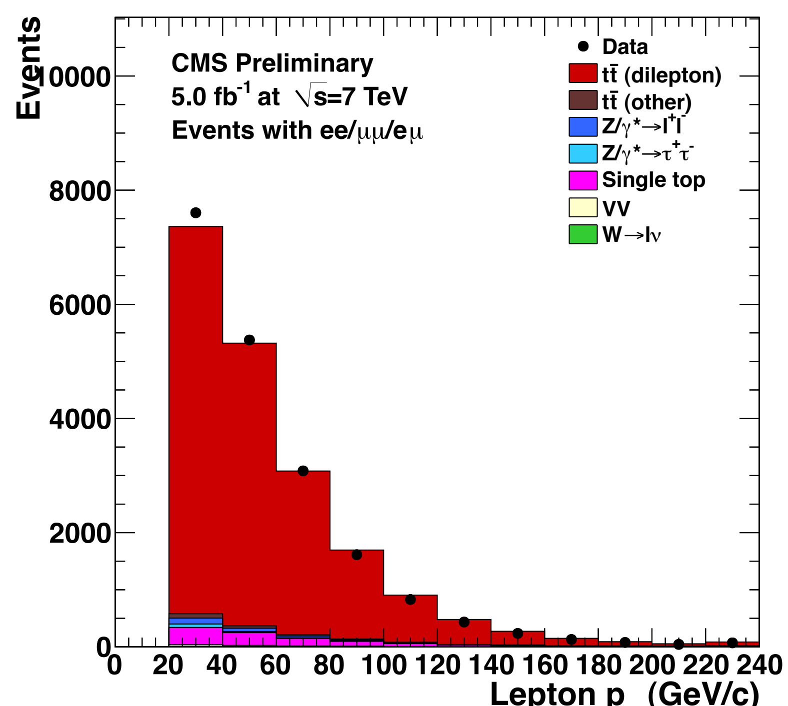
Data-MC comparison

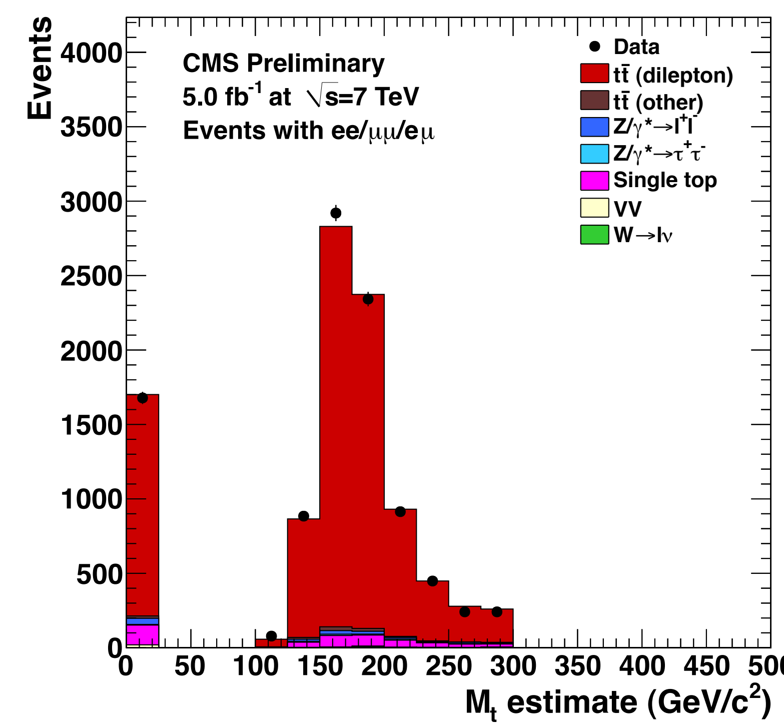




- Vertex reweighting has been applied to MC
- Selected plots: #btag jets, #vertices, MET, lepton p_T and reconstructed top mass
- Data and MC agreement is reasonable
- more plots in backup





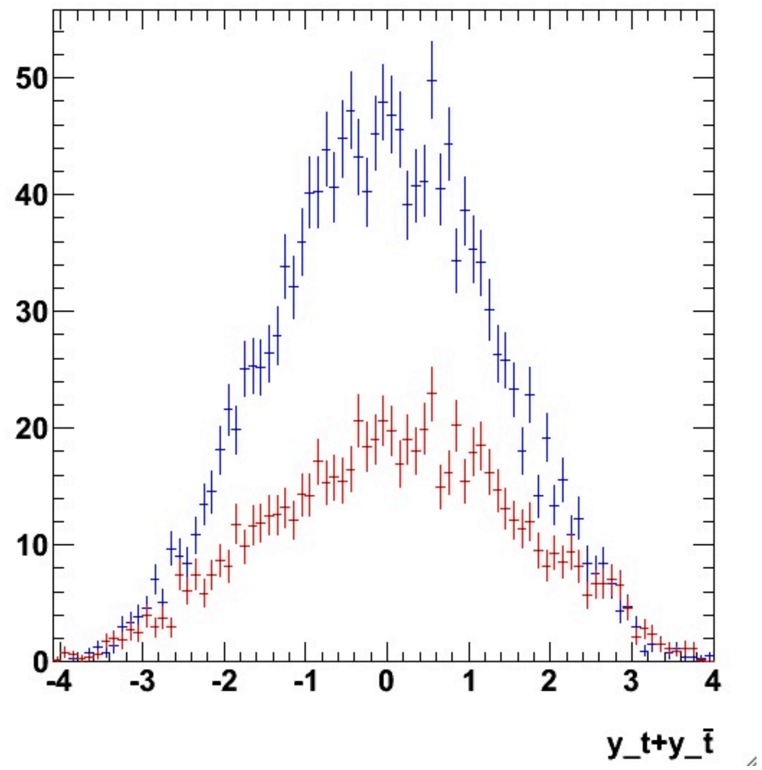


Reconstruction of Top kinematics

- Each $t\bar{t} \to \ell^+\ell^-$ event has 2 neutrinos.
- also ambiguity in combining b-jets and leptons from same top
- It is a challenge to reconstruct top mass
- We use the analytical matrix weighting technique (AMWT) described in http://arxiv.org/abs/arXiv:1105.5661
- Each events is reconstructed using a range of possible M_t values between 100-300 GeV in 1 GeV steps.
  - M_t value with the maximum averaged weight over possible solutions is taken
  - ttbar kinematics taken from solution with largest weight
- Events with no solutions are discarded (~17%)

Signal Regions

- Signal Region I: M_{tt} > 450 GeV
  - NP contribution expected to be enhanced at high M_{tt}
- Signal Region II: M_{tt} > 450 GeV and $|y_t+y_{tbar}|>2$
  - NP signal expected only in qqbar -> ttbar component
  - the gluon PDFs fall more rapidly at large x than the quark PDFs so gg -> ttbar tends to be more central than qqbar -> ttbar.



Red: from quark annihilation
Blue: from gluon fusion

- gg reduced to similar level as qqbar when $|y_t+y_{tbar}|>2$

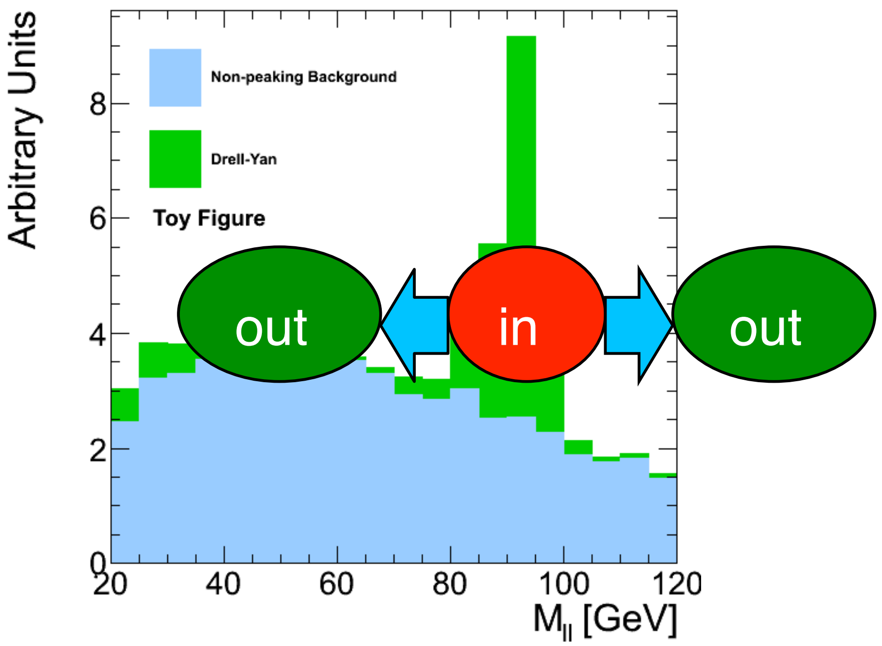
- Both signal regions also high purity (~92% $t\bar{t} \to \ell^+\ell^-$)

Background estimation

- We use the MC from the previous slides to estimate the background
- We make cross-checks for the DY and fake components using data-driven methods, and find reasonable agreement
- We then assign an appropriate background normalization systematic

Data-driven BG estimates: DY

- Estimate ee and μμ Drell-Yan using the method in CMS AN-2009-023:
  - $R_{out/in}$ method
- Use data in Z peak to predict DY yields in the signal region by propagating via the MC ratio out/in-peak



$$N_{\text{out}}^{\ell\ell,\text{exp}} = \overbrace{R_{\text{out/in}}^{\ell\ell}}^{\text{Z-peak to signal region ratio from MC, verified in data}} (\underbrace{N_{\text{in}}^{\ell\ell}}_{\text{same-flavor events in Z peak}} - \overbrace{N_{\text{in}}^{\text{non}-Z}}^{\text{opposite-flavor events in Z peak}})$$

- Estimate for pre-selection region: 142.4 ± 15.0 (stat+syst) events
  - consistent with MC prediction of 126.7 ± 8.7 events
- Estimate for Signal Region I: 47.6 ± 10.6 (stat+syst) events
  - consistent with MC prediction of 39.9 ± 4.8 events
- Estimate for Signal Region II: 10.8 ± 6.0 (stat+syst) events
  - consistent with MC prediction of 9.5 ± 2.4 events

Data-driven BG estimates: Fakes

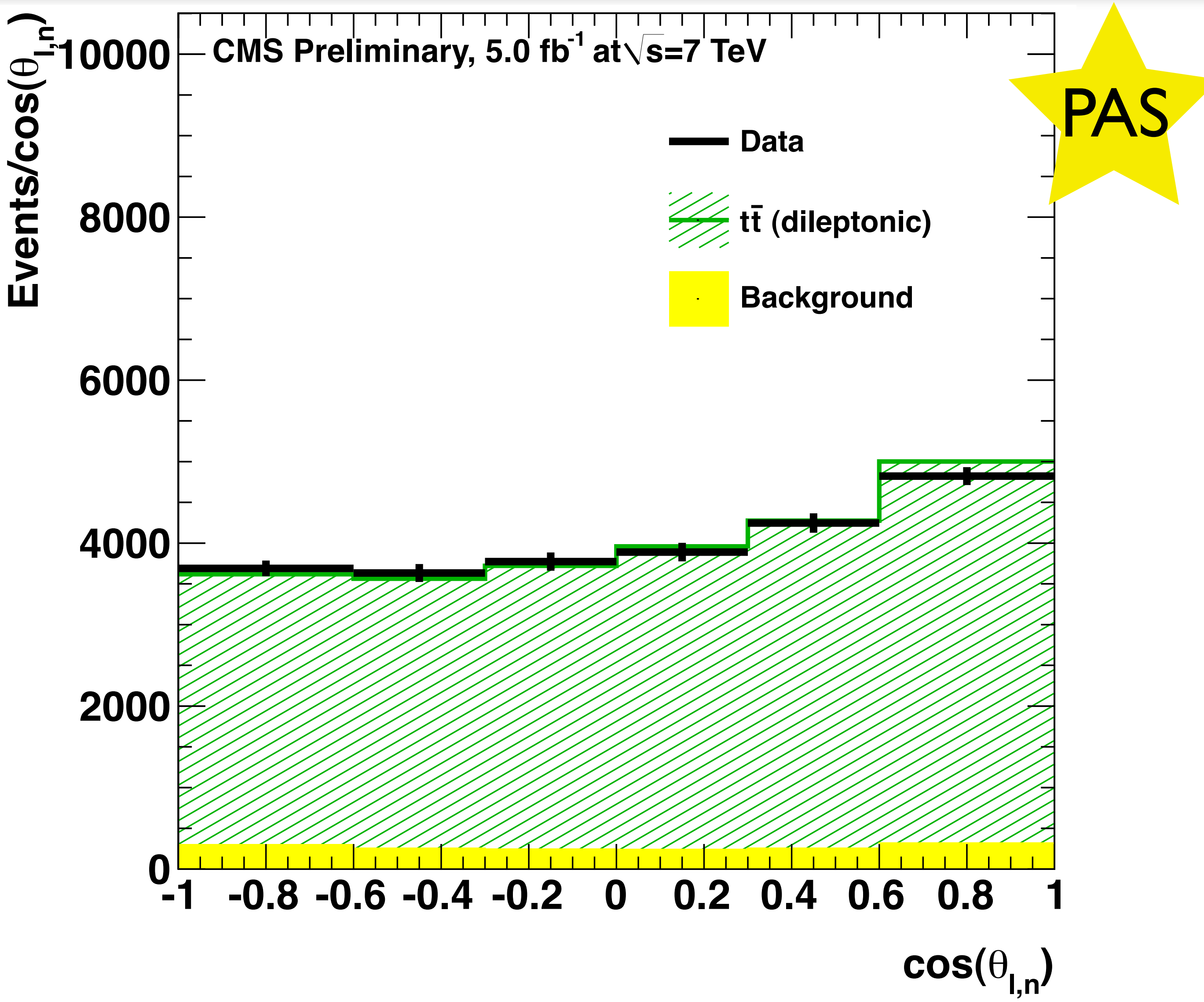
- Estimate contribution from fake leptons using the data-driven tight-to-loose method described in CMS AN-2010/257
  - measure tight-to-loose fake rates as a function of lepton P_T and eta
  - estimate number of fakes in data based on number of fakeable object (FOs). Weight each lepton+FO event by:
  - use MC to account for signal contamination in the FO sample
  - fake background primarily from ttbar- decaying to lepton+jets

$$\varepsilon_{fake}(p_T,\eta) = \frac{N_{pass\ tight}(p_T,\eta)}{N_{loose}(p_T,\eta)}$$

$$w_i = \frac{\epsilon_{\mathrm{fake}}(p_{\mathrm{T}i}, \eta_i)}{1 - \epsilon_{\mathrm{fake}}(p_{\mathrm{T}i}, \eta_i)}$$

- Estimate for pre-selection region: 138^{+281}_{-138} (stat+syst) events
  - consistent with MC prediction 100.1 ± 6.7 events
- Estimate for Signal Region I: $41.7^{+108.8}_{-41.7}$ (stat+syst) events
  - consistent with MC prediction of 47.1 ± 5.4 events
- Estimate for signal region: $6.6^{+16.4}_{-6.6}$ (stat+syst) events
  - consistent with MC prediction of 8.2 ± 2.5 events

Reco level asymmetries: preselection



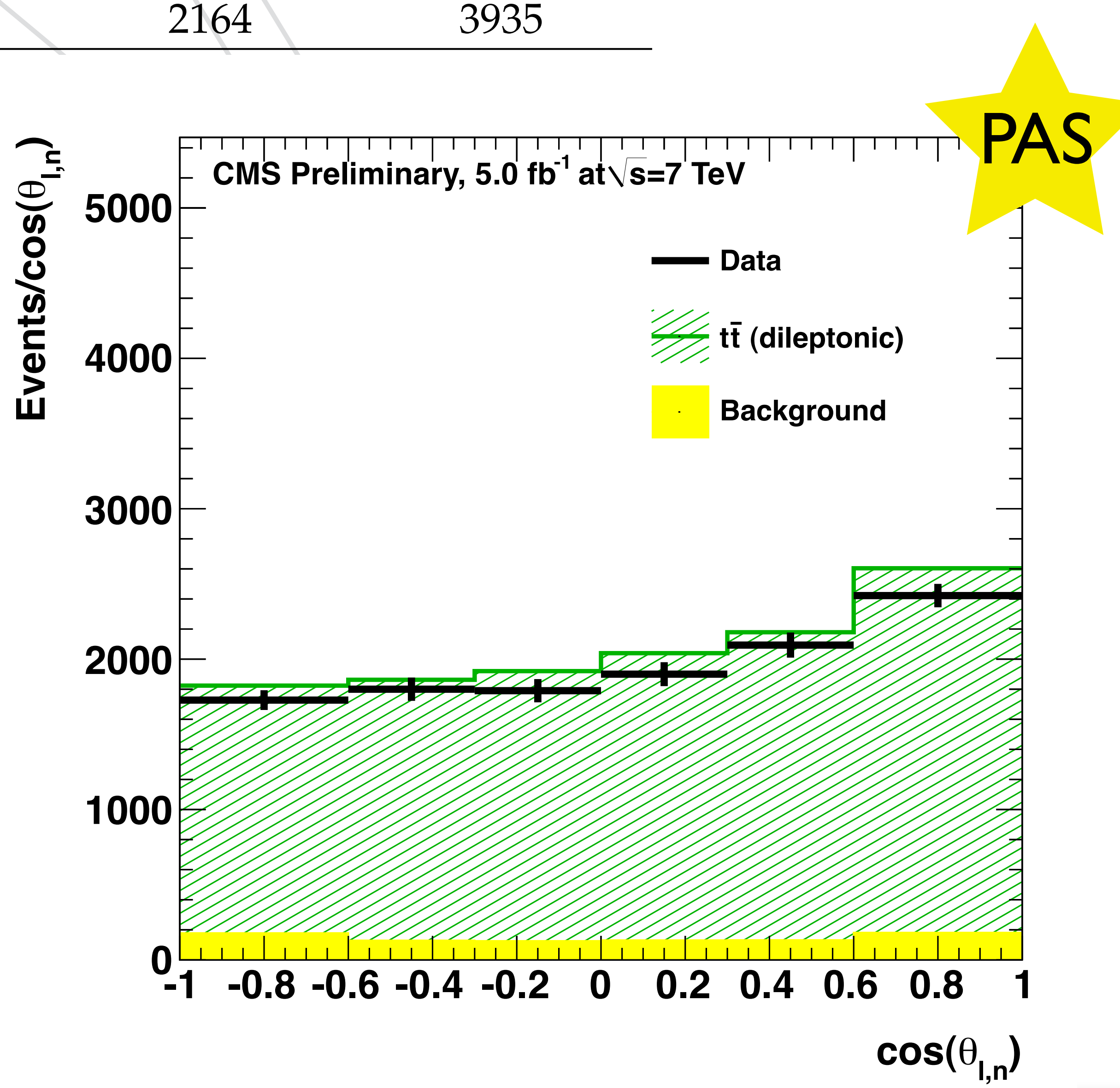
- Background is from the sum of all MC other than $t\bar{t} \to \ell^+\ell^-$
- Later we'll subtract this background and unfold to parton level
- For now, compare data and MC at reco level:
  - P_n = 0.083 ± 0.011 (stat) in data
  - P_n = 0.103 ± 0.002 (stat) in MC (sum of ttbar and background)

Reco level asymmetries: Signal Region I

PAS

Sample	ee	$\mu\mu$	$e\mu$	all
$t\bar{t} \to \ell^+\ell^-$	777.6 ± 2.9	921.4 ± 3.1	2143.0 ± 4.8	3842.0 ± 6.4
$t\bar{t} \to$ other	14.6 ± 2.0	1.5 ± 0.6	23.4 ± 2.4	39.6 ± 3.2
W + jets	0.0 ± 0.0	4.7 ± 3.3	2.8 ± 2.8	7.5 ± 4.4
DY$\to$ ee	13.8 ± 2.9	0.0 ± 0.0	0.0 ± 0.0	13.8 ± 2.9
DY$\to \mu\mu$	0.0 ± 0.0	25.6 ± 3.8	0.5 ± 0.5	26.1 ± 3.9
DY$\to \tau\tau$	7.4 ± 2.2	2.6 ± 1.2	8.0 ± 2.1	18.0 ± 3.3
Di-boson	3.9 ± 0.3	4.7 ± 0.3	9.7 ± 0.5	18.3 ± 0.6
Single top	32.8 ± 1.4	41.9 ± 1.6	101.3 ± 2.5	176.0 ± 3.3
Total (simulation)	850.2 ± 5.3	1002.4 ± 6.3	2288.7 ± 6.9	4141.4 ± 10.7
Data	801	970	2164	3935

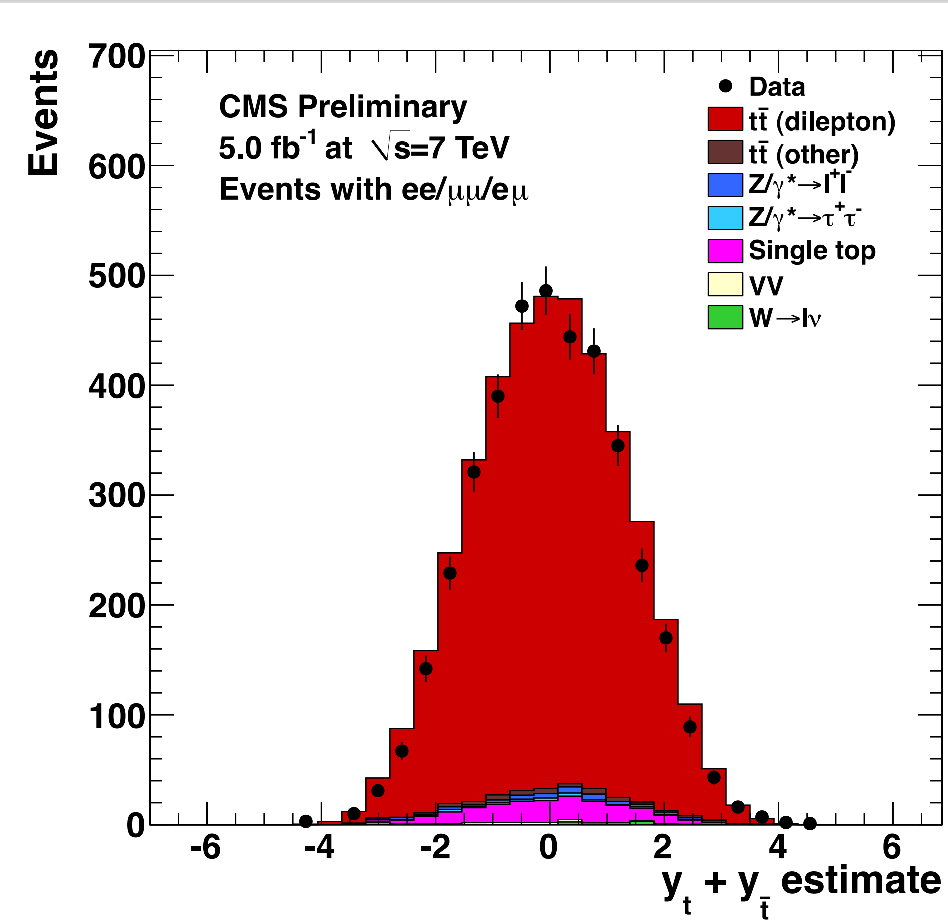
- Also compare data and MC at reco level in the signal regions
- Signal Region I:
  - $P_n = 0.101 \pm 0.016$ (stat) in data
  - $P_n = 0.106 \pm 0.003$ (stat) in MC
  - consistency is observed
- Signal Region II next slide



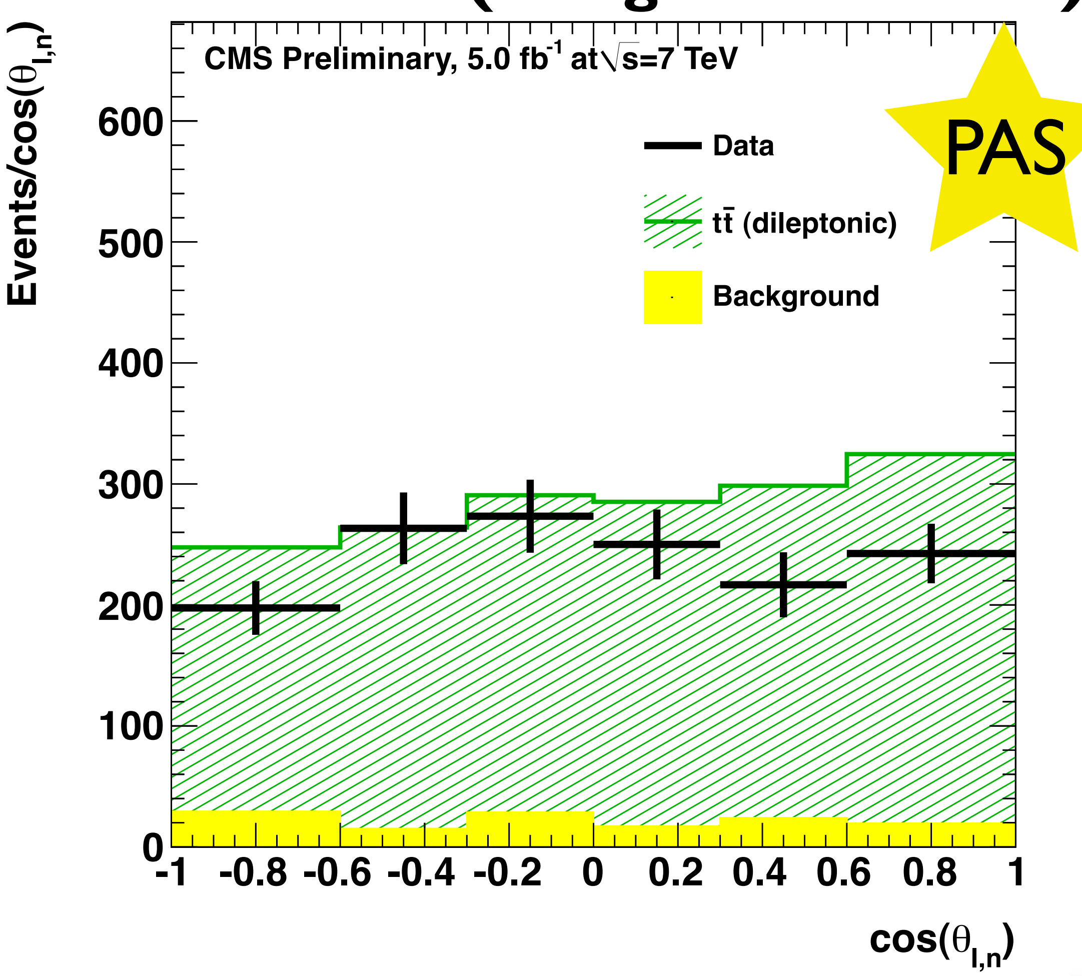
Reco level asymmetries: Signal Region II

PAS

Sample	ee	$\mu\mu$	$e\mu$	all
$t\bar{t} \to \ell^+\ell^-$	104.9 ± 1.1	124.1 ± 1.1	292.2 ± 1.8	$521.2 \pm$ [illegible]
$t\bar{t} \to$ other	2.8 ± 0.9	0.4 ± 0.3	2.8 ± 0.8	$6.0 \pm$ [illegible]
W + jets	0.0 ± 0.0	2.2 ± 2.2	0.0 ± 0.0	2.2 ± 2.2
DY$\to$ ee	2.5 ± 1.3	0.0 ± 0.0	0.0 ± 0.0	2.5 ± 1.3
DY$\to \mu\mu$	0.0 ± 0.0	6.5 ± 1.9	0.5 ± 0.5	7.0 ± 2.0
DY$\to \tau\tau$	0.0 ± 0.0	1.0 ± 0.7	0.9 ± 0.7	1.9 ± 1.0
Di-boson	0.7 ± 0.1	0.5 ± 0.1	1.4 ± 0.2	2.5 ± 0.2
Single top	3.7 ± 0.5	5.9 ± 0.6	13.4 ± 0.9	23.0 ± 1.2
Total (simulation)	114.5 ± 1.9	140.7 ± 3.3	311.2 ± 2.3	566.3 ± 4.5
Data	103	116	258	477



K-S = 0.18 (using narrow bins)



- MC total yield 19% more than data
  - (y_t+y_{tbar}) more peaked in data
  - normalization does not affect value of polarization
- $P_n = -0.006 \pm 0.046$ (stat) in data
- $P_n = 0.069 \pm 0.008$ (stat) in MC
- consistent within large uncertainty

Unfolding I

- Selection cuts and detector response are modelled by the acceptance (A) and smearing (S) matrices

- Given a true binned distribution x_i we observe b_k in our detector (after background subtraction):

$$b_k = S_{kj} A_{ji} x_i$$

Inversion:

$$x = A^{-1} S^{-1} b$$

S – migration matrix, A – acceptance matrix.

A is diagonal, S has off-diagonal elements due to migration from one bin to another

- We use regularized unfolding based on Singular Value Decomposition (SVD)
    - implemented in ROOT compatible package RooUnfold
    - SVD approach to data unfolding (Hocker and Kartvelishvili hep-ph/9509307)

Unfolding II

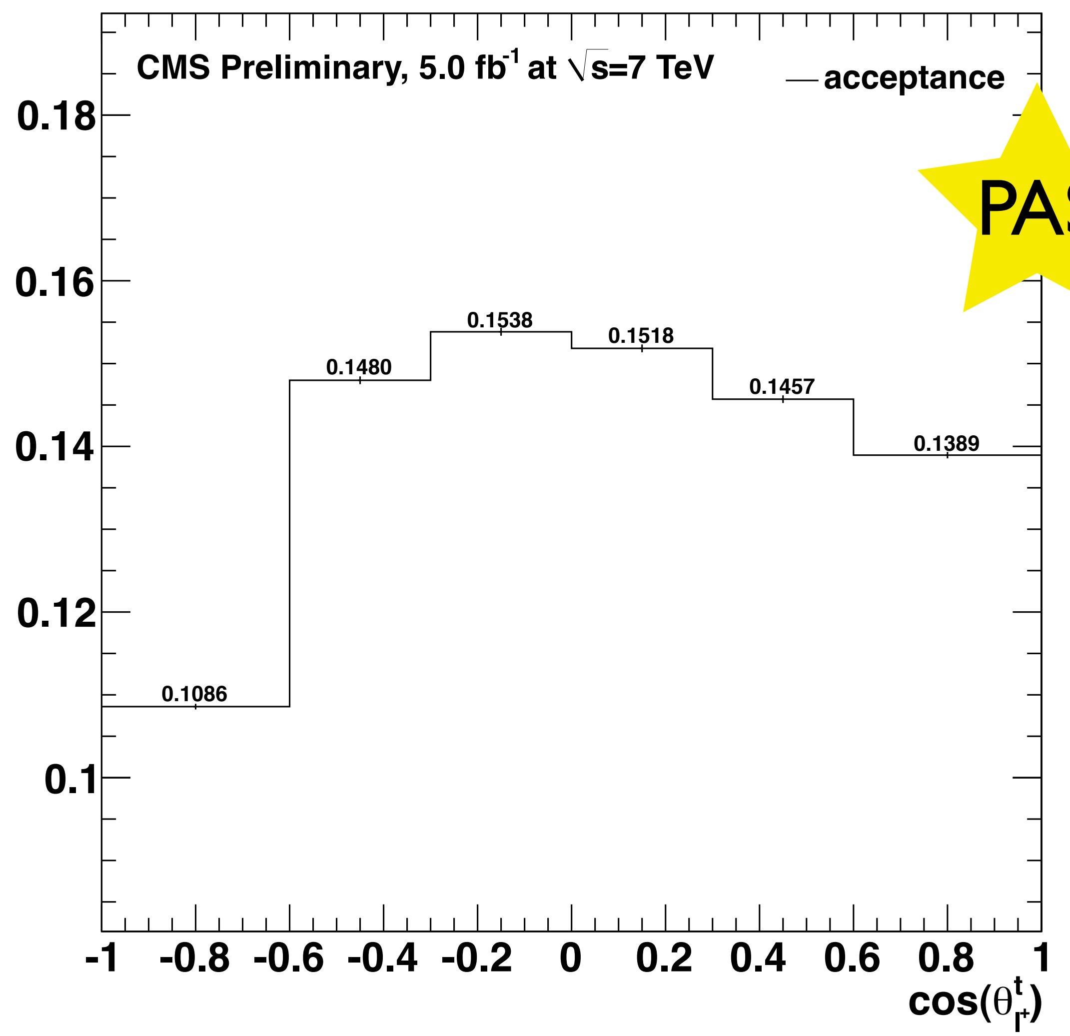
- Performed extensive tests using pseudo-experiments to ensure proper performance of the unfolding algorithm

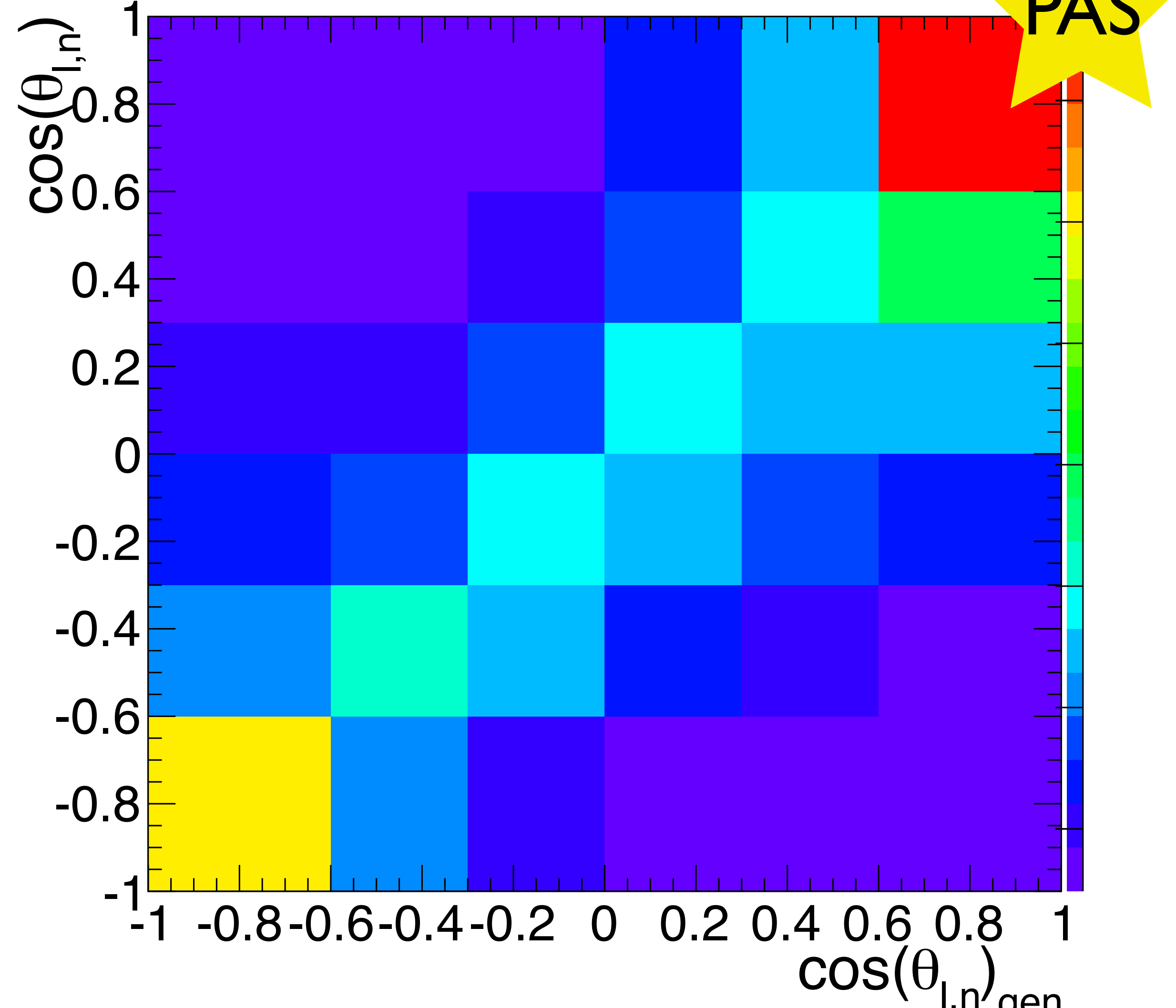
PAS

- We use 6 bins for unfolding:

B1	B2	B3	B4	B5	B6
[-1.0,-0.6]	[-0.6,-0.3]	[-0.3,-0.0]	[0.0, 0.3]	[0.3, 0.6]	[0.6, 1.0]

- Acceptance matrix and smearing matrix bins:





Systematics

PAS

- Systematics are evaluated on the unfolded result

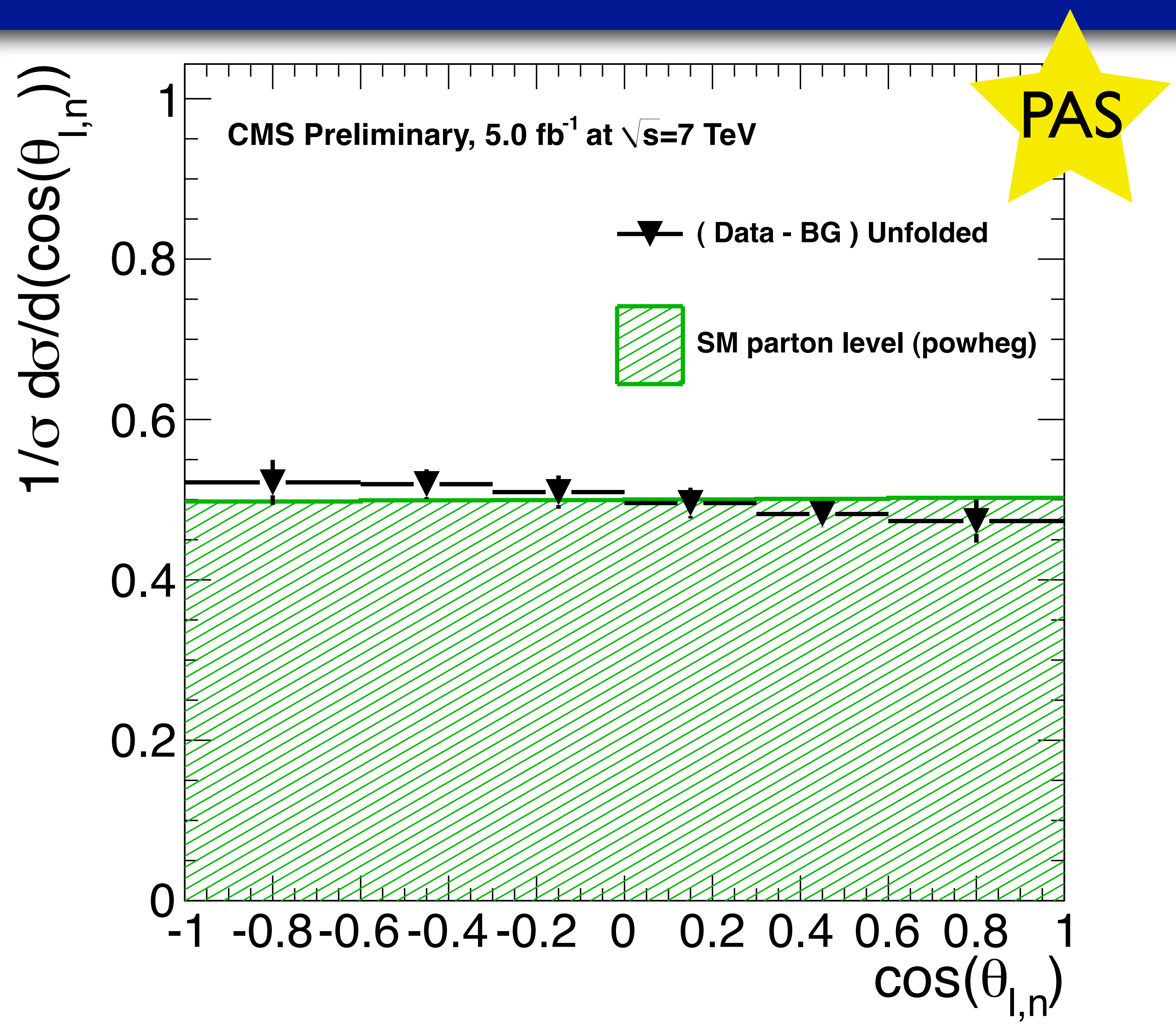
Table 6: Systematic uncertainties.

JES	BG	modeling	unfolding	top mass	$b-$tagging	Trigg(lep ID)	PU	Total
0.043	0.009	0.014	0.009	0.019	0.001	0.000	0.002	0.050

matching: 0.004

- JES is the dominant systematic
  - calculated assuming a 7.5% uncertainty on the hadronic energy scale (after L1FastL2L3 correction)
  - this directly affects the shape of the $\cos\theta_{\ell,n}$ distribution
- For BG we vary normalizations by 100% (DY and fakes) or 50% (for the single top background, which is dominant)
- Most other systematics assessed by varying the model used to calculate the unfolding (i.e. changing A and S matrices)
  - PU and b-tagging and trig/lep ID eff from reweighting powheg MC
  - modeling, matching, top mass from MC@NLO and madgraph MC
- Small unfolding bias (0.9%) also gives a systematic

Unfolded results



- Plot shows unfolded parton level differential cross section compared to the SM (from powheg truth level)
  - $P_n = -0.035 \pm 0.028 \pm 0.050$ from data
  - $P_n = 0.003 \pm 0.0004$ in MC (parton level, no cuts)
- Result in data is consistent with the SM

Summary

- Performed an analysis measuring top polarization
  - NP responsible for Tevatron A_{fb} could cause deviation from SM
- Backgrounds predicted by MC, but checked using data-driven methods and conservative normalization systematics calculated
- Measure P_n at parton level using unfolding technique (extensively validated)
  - $P_n = -0.035 \pm 0.028 \pm 0.050$
  - consistent with SM expectation of ~0
- Also compare $\cos\theta_{\ell,n}$ distribution between data and MC at reco level in 2 signal regions, where NP contribution expected enhanced
  - no significant deviation observed

Backup

Previous presentations

Previous presentations by Yanjun Tu, Jacob Linacre and Sergo Jindariani in top properties group meetings:

https://indico.cern.ch/getFile.py/access?contribId=1&resId=0&materialId=slides&confId=180584

http://indico.cern.ch/getFile.py/access?contribId=8&sessionId=0&resId=0&materialId=slides&confId=180655

http://indico.cern.ch/getFile.py/access?contribId=1&resId=0&materialId=slides&confId=187624

https://indico.cern.ch/getFile.py/access?contribId=2&resId=0&materialId=slides&confId=190610

https://indico.cern.ch/getFile.py/access?contribId=3&resId=0&materialId=slides&confId=191553

Event Samples

- TTJets_TuneZ2_7TeV-madgraph-tauola_Summer11-PU_S4_START42_V11-v1 , 154 pb
- TTTo2L2Nu2B_7TeV-powheg-pythia6_Summer11-PU_S4_START42_V11-v1 , 16.2 pb
- /TT_TuneZ2_7TeV-mcatnlo/Fall11-PU_S6_START42_V14B-v1/AODSIM , 154 pb
- T_TuneZ2_tW-channel_7TeV-madgraph_Summer11-PU_S4_START42_V11-v1 , 7.87 pb
- T_TuneZ2_t-channel_7TeV-madgraph_Summer11-PU_S4_START42_V11-v1 , 41.92 pb
- T_TuneZ2_s-channel_7TeV-madgraph_Summer11-PU_S4_START42_V11-v1 , 3.19 pb
- Tbar_TuneZ2_tW-channel_7TeV-madgraph_Summer11-PU_S4_START42_V11-v1 , 7.87 pb
- Tbar_TuneZ2_t-channel_7TeV-madgraph_Summer11-PU_S4_START42_V11-v1 , 22.65 pb
- Tbar_TuneZ2_s-channel_7TeV-madgraph_Summer11-PU_S4_START42_V11-v1 , 1.44 pb
- WJetsToLNu_TuneZ2_7TeV-madgraph-tauola_Summer11-PU_S4_START42_V11-v1 , 31314 pb
- DYJetsToLL_TuneD6T_M-50_7TeV-madgraph-tauola_Summer11-PU_S4_START42_V11-v1 , 3048 pb
- DYToEE_M-20_CT10_TuneZ2_7TeV-powheg-pythia_Summer11-PU_S4_START42_V11-v1 , 1666 pb
- DYToMuMu_M-20_CT10_TuneZ2_7TeV-powheg-pythia_Summer11-PU_S4_START42_V11-v1 , 1666 pb
- DYToTauTau_M-20_CT10_TuneZ2_7TeV-powheg-pythia-tauola_Summer11-PU_S4_START42_V11-v1 , 1666 pb
- DYToEE_M-10To20_TuneZ2_7TeV-pythia6_Summer11-PU_S4_START42_V11-v1 , 3319.61 pb
- DYToMuMu_M-10To20_TuneZ2_7TeV-pythia6_Summer11-PU_S4_START42_V11-v1 , 3319.61 pb
- DYToTauTau_M-10To20_CT10_TuneZ2_7TeV-powheg-pythia-tauola_Summer11-PU_S4_START42_V11-v2 , 3319.61 pb
- WWJetsTo2L2Nu_TuneZ2_7TeV-madgraph-tauola_ummer11-PU_S4_START42_V11-v1, 4.783 pb
- WZJetsTo2L2Q_TuneZ2_7TeV-madgraph-tauola_Summer11-PU_S4_START42_V11-v1, 1.786 pb
- WZJetsTo3LNu_TuneZ2_7TeV-madgraph-tauola_Summer11-PU_S4_START42_V11-v1, 0.856 pb
- ZZJetsTo2L2Nu_TuneZ2_7TeV-madgraph-tauola_Summer11-PU_S4_START42_V11-v1, 0.30 pb
- ZZJetsTo2L2Q_TuneZ2_7TeV-madgraph-tauola_Summer11-PU_S4_START42_V11-v1, 1.0 pb
- ZZJetsTo4L_TuneZ2_7TeV-madgraph-tauola/_Summer11-PU_S4_START42_V11-v1, 0.076 pb
- /Wprime_SM_400_Madgraph_v2/yanjuntu-Wprime_SM_400_Madgraph_v2-f3d3f52ad6235ba5a3ccb05162c152b9/USER
- /Wprime_ttbar_600_Madgraph/yanjuntu-Wprime_ttbar_600_Madgraph-f3d3f52ad6235ba5a3ccb05162c152b9/USER
- AxigluonR_2TeV_ttbar_MadGraph_sergo-AxigluonR_2TeV_ttbar_MadGraph

- Data: May10th rereco + Prompt v4 + Aug05th rereco + Prompt v6 + 2011B Data (5.0 fb^{-1})

Triggers

- Double Electron
  - HLT_Ele17_CaloIdL_CaloIsoVL_Ele8_CaloIdL_CaloIsoVL
  - HLT_Ele17_CaloIdT_TrkIdVL_CaloIsoVL_TrkIsoVL_Ele8_CaloIdT_TrkIdVL_CaloIsoVL_TrkIsoVL
  - HLT_Ele17_CaloIdT_CaloIsoVL_TrkIdVL_TrkIsoVL_Ele8_CaloIdT_CaloIsoVL_TrkIdVL_TrkIsoVL
- Double Muon
  - HLT_DoubleMu7
  - HLT_Mu13_Mu7
  - HLT_Mu13_Mu8
  - HLT_Mu17_Mu8
- Electron Muon
  - HLT_Mu17_Ele8_CaloIdL
  - HLT_Mu8_Ele17_CaloIdL
  - HLT_Mu17_Ele8_CaloIdT_CaloIsoVL
  - HLT_Mu8_Ele17_CaloIdT_CaloIsoVL

Trigger efficiencies

For the high p_T dilepton triggers, the efficiencies listed in Table 1, Table 2, Table 3 and Table 4 are applied to ee, $\mu\mu$ and $e\mu$ Monte Carlo Events. Details of the measurement of the trigger efficiencies are described in [12].

Table 1: The efficiency of the leading leg requirement for the double electron trigger, averaged over the full 2011 data.

Measurement	$0.0 \leq \lvert\eta\rvert < 1.5$	$1.5 \leq \lvert\eta\rvert < 2.5$
$20 \leq p_T \leq 30$	0.9849 ± 0.0003	0.9774 ± 0.0007
$p_T > 30$	0.9928 ± 0.0001	0.9938 ± 0.0001

Table 2: The efficiency of the trailing leg requirement for the double electron trigger, averaged over the full 2011 data.

Measurement	$0.0 \leq \lvert\eta\rvert < 1.5$	$1.5 \leq \lvert\eta\rvert < 2.5$
$20 \leq p_T \leq 30$	0.9923 ± 0.0002	0.9953 ± 0.0003
$p_T > 30$	0.9948 ± 0.0001	0.9956 ± 0.0001

Table 3: The efficiency of the leading leg requirement for the double muon trigger, averaged over the full 2011 data.

Measurement	$0.0 \leq \lvert\eta\rvert < 0.8$	$0.8 \leq \lvert\eta\rvert < 1.2$	$1.2 \leq \lvert\eta\rvert < 2.1$	$2.1 \leq \lvert\eta\rvert < 2.4$
$20 \leq p_T \leq 30$	0.9648 ± 0.0007	0.9516 ± 0.0013	0.9480 ± 0.0009	0.8757 ± 0.0026
$p_T > 30$	0.9666 ± 0.0003	0.9521 ± 0.0005	0.9485 ± 0.0004	0.8772 ± 0.0012

Table 4: The efficiency of the trailing leg requirement for the double muon trigger, averaged over the full 2011 data.

Measurement	$0.0 \leq \lvert\eta\rvert < 0.8$	$0.8 \leq \lvert\eta\rvert < 1.2$	$1.2 \leq \lvert\eta\rvert < 2.1$	$2.1 \leq \lvert\eta\rvert < 2.4$
$20 \leq p_T \leq 30$	0.9655 ± 0.0007	0.9535 ± 0.0013	0.9558 ± 0.0009	0.9031 ± 0.0023
$p_T > 30$	0.9670 ± 0.0003	0.9537 ± 0.0005	0.9530 ± 0.0004	0.8992 ± 0.0011

Lepton selections

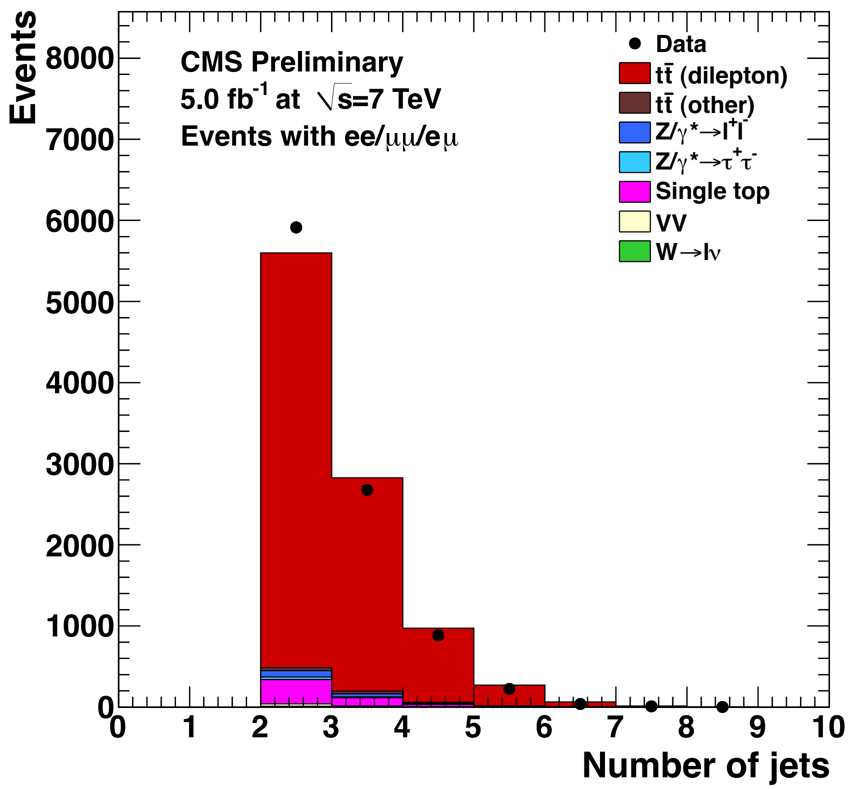
Electron selection

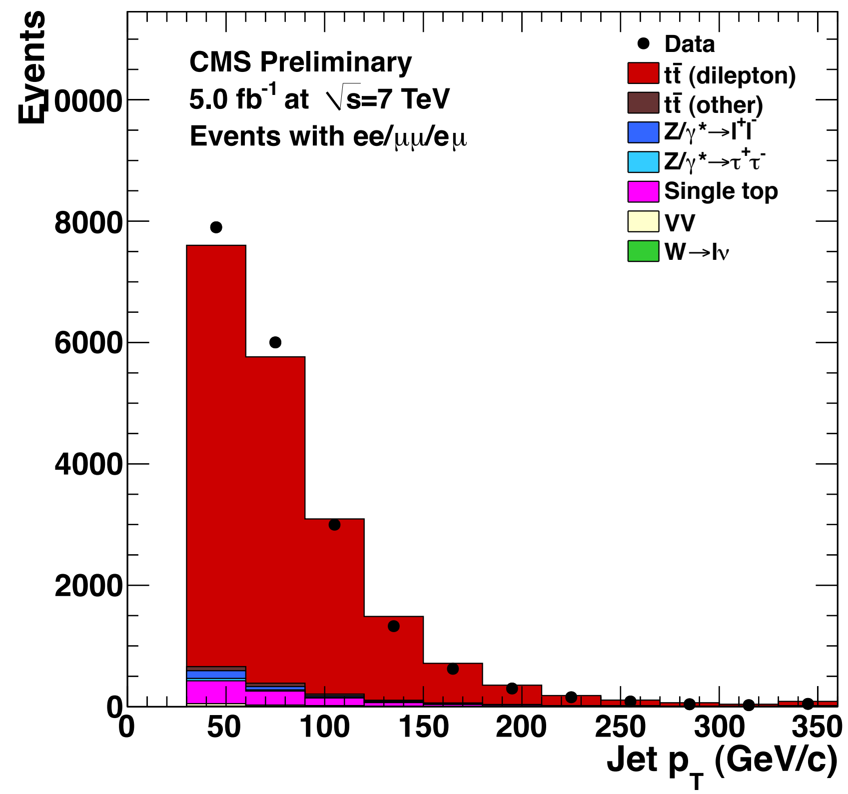
- p_T > 20 GeV; |eta| < 2.5
- VBTF90 (cuts tightened to match CaloId+TrkIdVL HLT requirements)
- d0 (PV) < 0.04 cm, dz (PV) < 1 cm --calculated w.r.t. 1st good DA PV
- no muon $\Delta R < 0.1$
- <=1 miss hits, |dist| < 0.02 cm and < 0.02, CMS AN-2009-159
- Veto electrons with a supercluster in the transition region (1.44 <|eta| < 1.56)
- iso/p_T < 0.15 (EB pedestal subtraction 1 GeV, no fastjet correction)
- ecaliso/p_T < 0.2

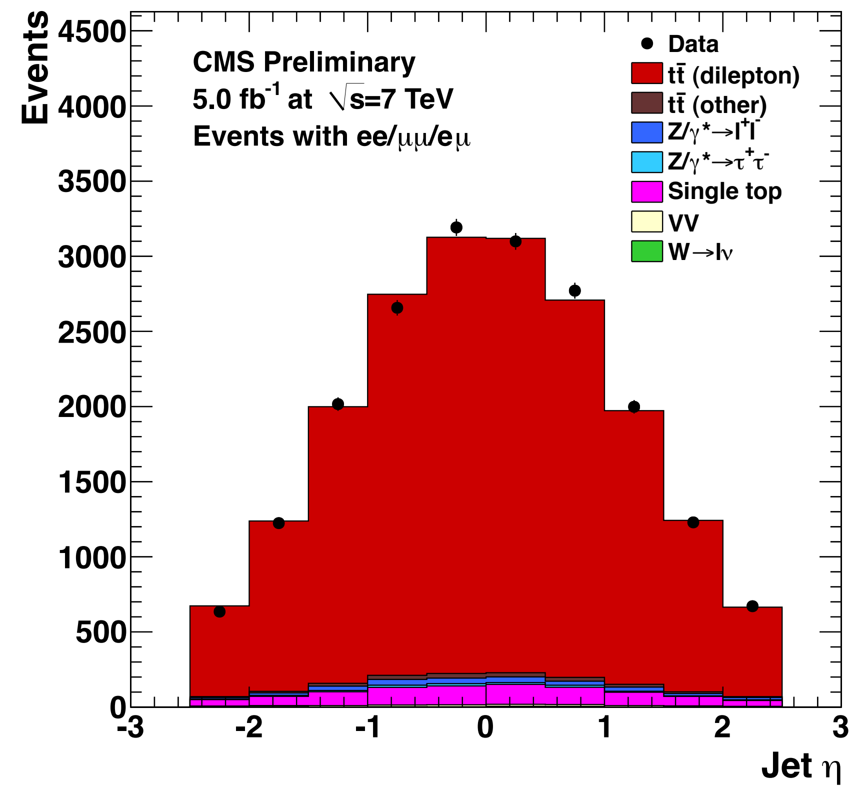
Muon selection

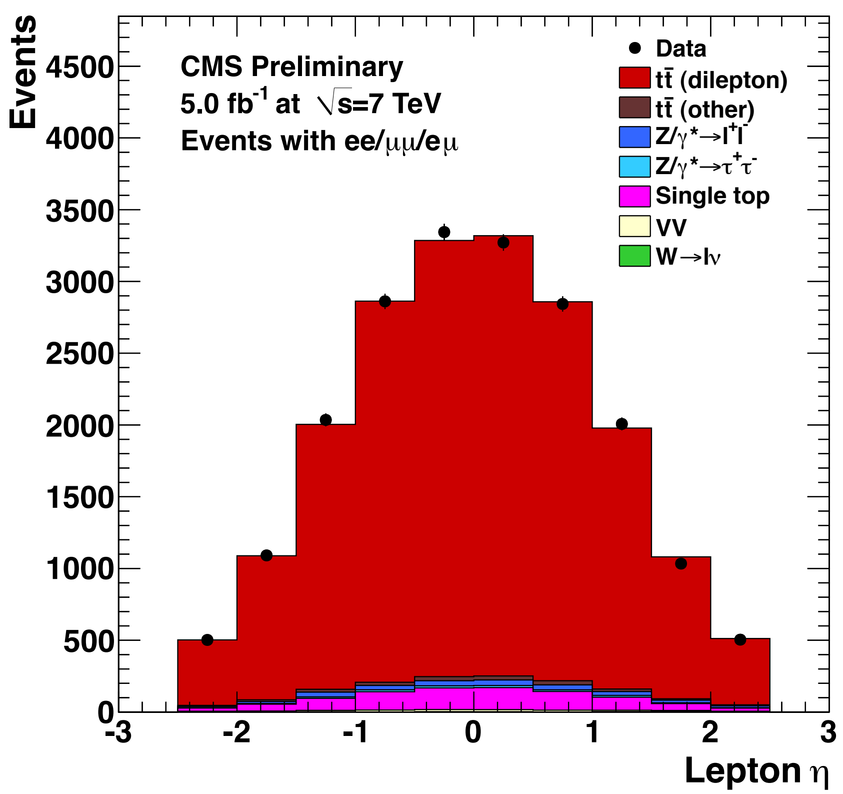
- p_T > 20 GeV; |eta| < 2.4
- global and tracker muon
- chi^2/ndf < 10
- nValidHits > 10 -- to be updated to frac of validHits
- valid StandAloneHits > 0
- d0 (PV) < 0.02 cm, dz (PV) < 1 cm --calculated w.r.t. 1st good DA PV
- (p_T)/p_T < 0.1
- iso/p_T < 0.15 (no fastjet correction)

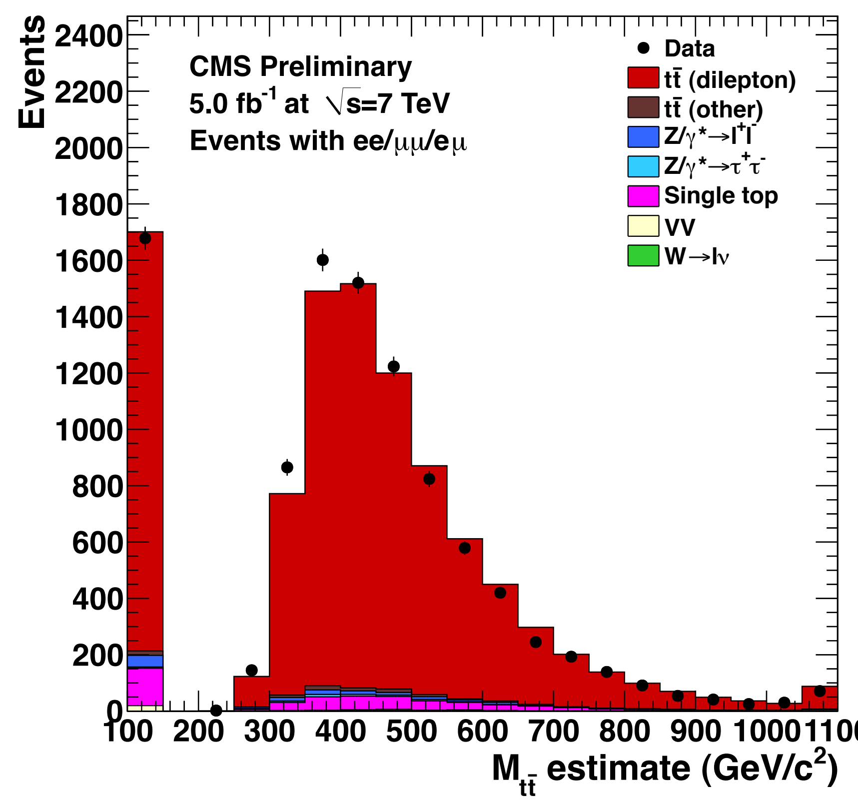
Data-MC comparison II

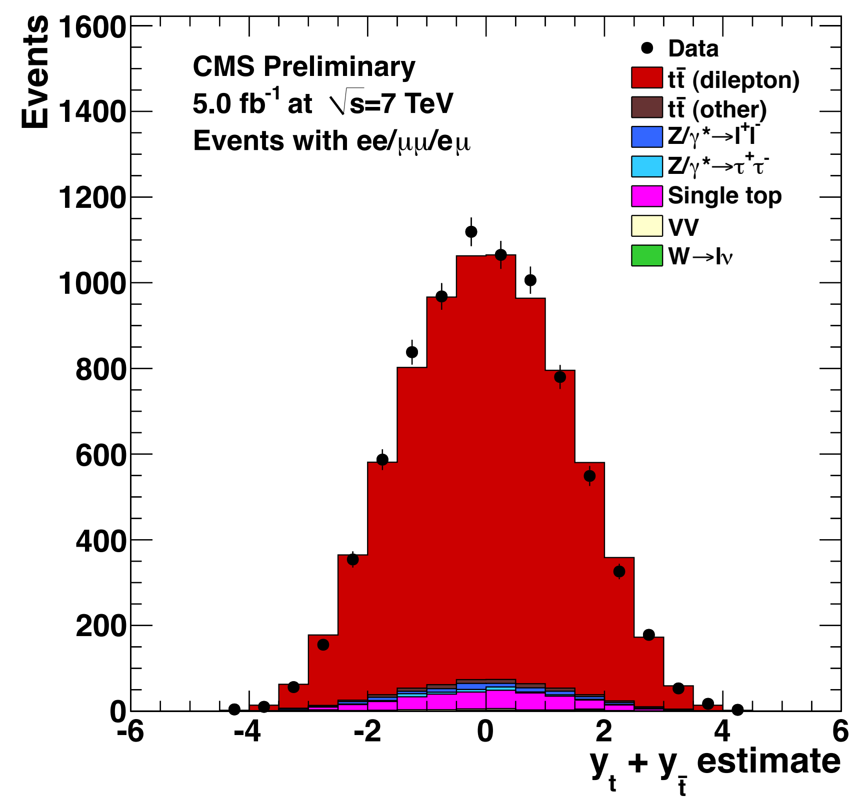












choice of ttbar MC

- We compare data to sum of MC in the preselection region, using the 3 different ttbar samples for the ttbar->dilepton component
  - TTJets_TuneZ2_7TeV-madgraph-tauola: madgraph sample, no spin correlations between top and tbar
  - TTTo2L2Nu2B_7TeV-powheg-pythia6: powheg dilepton sample, with spin correlations
  - TT_TuneZ2_7TeV-mcatnlo: MC@NLO sample, with spin correlations
- All other background samples (including tt->other) are kept the same
- All distributions are normalised to unity (shape comparison only)
  - asymmetry measurements are only sensitive to the shape
  - K-S calculated using narrow binning

ttbar MC comparison summary

- Asymmetry values and K-S vs data, for preselection region
  - for variables requiring top reconstruction, only events with solution are used

Variable	Value powheg	Value mc@nlo	Value madgraph	K-S powheg	K-S mc@nlo	K-S madgraph
Lepton charge asym	0.002±0.002	0.000±0.003	-0.002±0.005	0.60	0.85	0.22
Lepton azimuthal asym	-0.171±0.002	-0.115±0.002	-0.273±0.005	0.08	1e-4	2e-25
Top charge asymmetry	0.005±0.002	0.005±0.003	-0.005±0.006	0.20	0.55	0.01
Top polarisation	0.103±0.002	0.109±0.003	0.097±0.006	0.19	0.06	0.49
Top spin correlation	-0.087±0.002	-0.108±0.003	-0.068±0.006	0.12	1e-4	0.42

- powheg dilepton ttbar sample seems to best represent the data for these variables

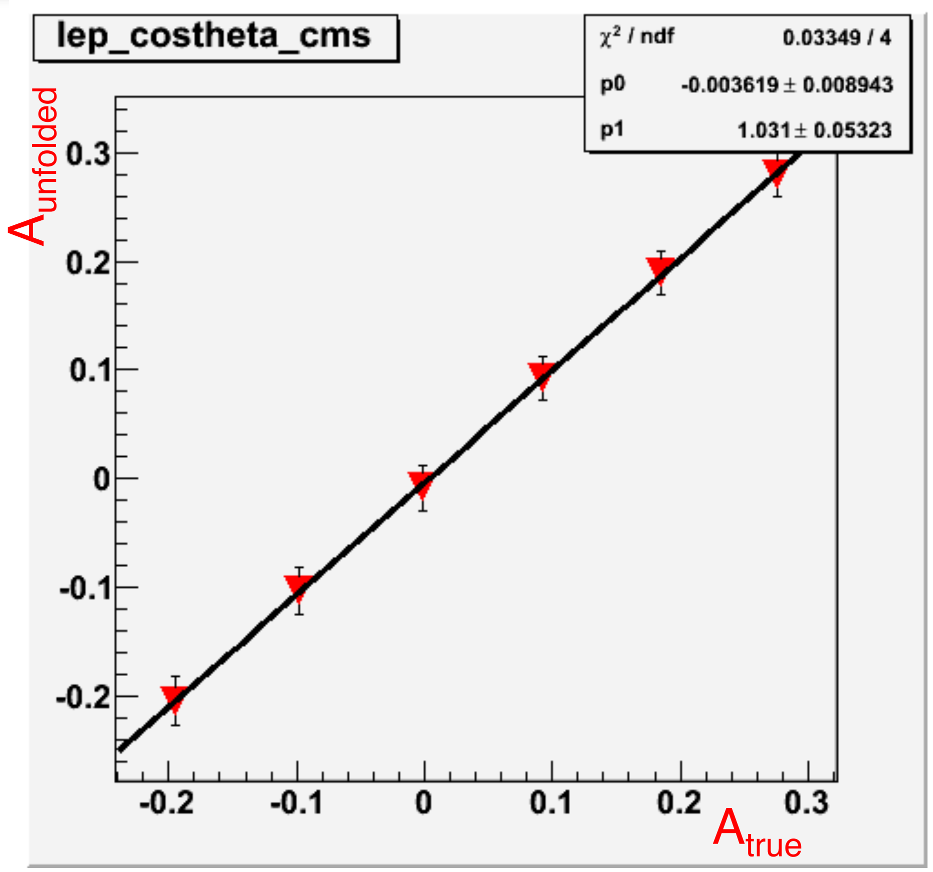
Unfoldinging: linearity check I

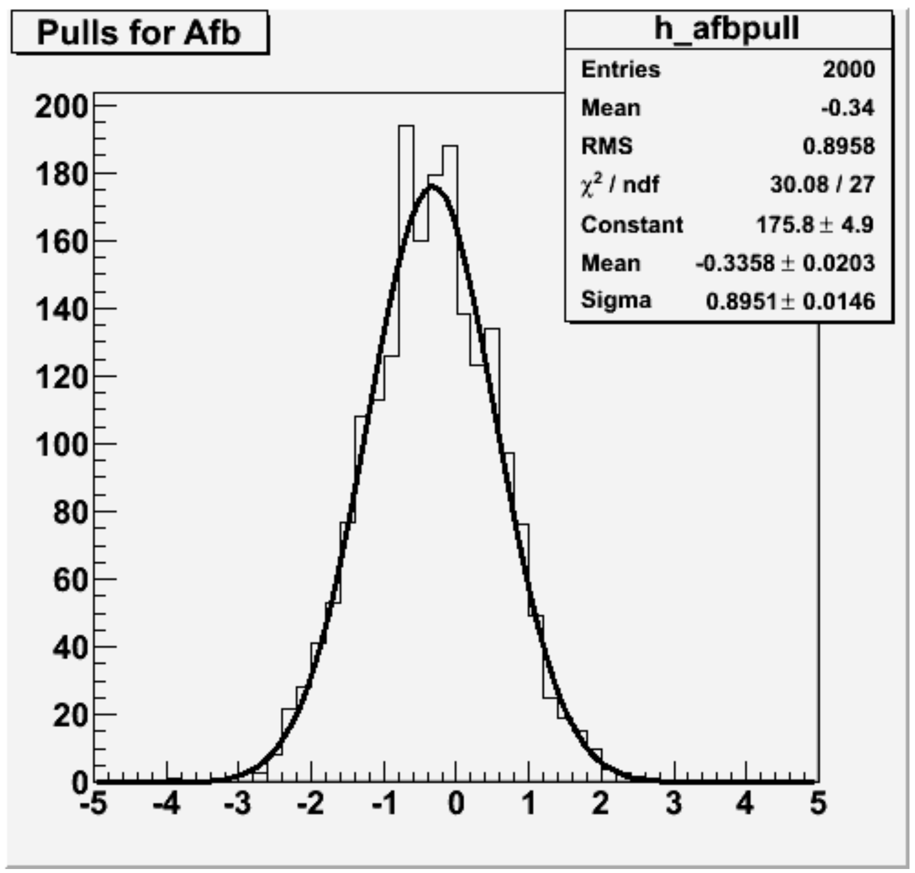
- start from ttbar in the pre-selection region
- most of our variables have no asymmetry for top
- introduce artificial asymmetry by reweighting events based on generator level quantity, for example:
  - if we are measuring Afb($|\eta_{l+}|$ - $|\eta_{l-}|$) then reweight events as:

    weight=1+K(($|\eta_{l+}|$ - $|\eta_{l-}|$))
  - vary K from -0.5 to 0.5 with 0.2 steps
  - covers much larger Afb range than expected from new physics

- Generate pseudo-experiments by fluctuating reweighted distribution, unfold every time
- 2000 pseudo-experiments
- Compare average to the true value

Unfolding: linearity check II





True	Measured	Unfolded
-0.19 +-0.011	-0.036+-0.011	-0.20+-0.022
-0.097+-0.011	0.02+-0.012	-0.10+-0.021
-0.002+-0.011	0.076+-0.011	-0.008+-0.021
0.092+-0.011	0.13+-0.011	0.092+-0.021
0.18+-0.011	0.18+-0.011	0.19+-0.02
0.28+-0.011	0.24+-0.011	0.28+-0.02

- Small Bias in the mean: assign systematic uncertainty
- Slight over-estimation of the uncertainty (we don't correct this)